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Species Composition of the Harmful Entomocomplex of Sorghum (*Sorghum bicolor* (L.) Moench) in the Polissia Region of Ukraine

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Grain sorghum (*Sorghum bicolor* (L.) Moench) is an important cereal crop that demonstrates high ecological plasticity and drought tolerance, making it a promising alternative to traditional spring crops in the face of climate change. Despite its many advantages, sorghum crops are accompanied by increased exposure to pests, which can reduce yields by up to 72%. During 2018-2024, a comprehensive study of the sorghum pest complex was conducted in Polissia region of Ukraine. Crop monitoring revealed 13 pest species belonging to 4 orders: Coleoptera, Homoptera, Lepidoptera and Diptera. The most harmful species were *Rhopalosiphum maidis* Fitch, *Schizaphis graminum* Rond., *Octrinia nubilalis* Hb., *Scotia segetum* Schiff., *Macrosteles laevis* Rib., whose frequency of occurrence in the phases of active crop development exceeded 50%. Damage to plants by aphids and cicadas led to a significant decrease in grain quality due to impaired photosynthetic activity, and caterpillars of the scoop and stem butterfly caused plant death. The study revealed the dependence of phytophagous reproduction on abiotic factors, in particular unstable moisture and high temperatures, which affected their seasonal dynamics. The highest pest activity was observed during the tillering and grain filling phases. The results provide the basis for the development of integrated sorghum protection systems, including a combination of agronomic and biological measures, which will reduce yield losses by up to 30%. The study of the species composition of pests is important for increasing the efficiency of sorghum cultivation in Polissia of Ukraine.

Keywords: Climate change, crops productivity, biotic and abiotic stress, drought resistant, phytophagous insects, entomocomplex.

INTRODUCTION

Climate change is one of the most serious global threats to agriculture today, requiring farmers to adapt to new conditions. As a result, agriculture faces critical problems, the most significant of which are rising temperatures, changes in precipitation patterns, more extreme weather events, and declining soil fertility. These factors lead to a decline in the yield of traditional crops, which requires the search for new ones with increased adaptive resistance to biotic and abiotic environmental factors (Andersson et al., 2014; Boiko, 2016; Calvo, 2014, Chaâbene et al., 2015). In Ukraine, the Polissia region is particularly vulnerable, characterized by complex edaphic and climatic conditions: acidic sod-podzolic soils, frequent periods of waterlogging, and alternating dry and rainy years. Under such conditions, traditional crops (wheat, corn, barley) demonstrate reduced yield stability (Boiko, 2016; Kucher et al., 2022; Stoliar & Trembitska, 2025). Therefore, there is an urgent need to introduce alternative crops with increased tolerance to biotic and abiotic stresses. Therefore, the issue of introducing grain sorghum into the agricultural sector of Polissia, Ukraine, is particularly relevant. The region, characterized by difficult weather and soil conditions, faces a whole range of challenges caused by climate change: increased frequency and intensity of droughts, soil erosion, alternating periods of intense heat and prolonged rainfall are just some of the problems facing local farmers. In addition, climate change causes disturbances in ecosystems, which, in our situation, affects pest populations that can reduce the efficiency of growing new crops, in particular sorghum (Ahmad et al., 2016; Malschi et al., 2015; Okosun et al., 2021; Ren et al., 2017). Common sorghum

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(*Sorghum bicolor* (L.) Moench) is considered the most drought-resistant among cereals due to its ability to reduce transpiration losses, form a powerful root system, and use minimal moisture reserves. Sorghum has a high water consumption coefficient, which allows it to produce a harvest even in conditions of insufficient rainfall (Hammer et al., 2014; Kahsay et al., 2018). According to FAO data, this crop ranks fifth among the world's cereals and is grown in more than 100 countries. In Africa and Asia, it is a staple of food security, while in the US, Australia, and Argentina, it is an important component of the feed and bioenergy system. For Ukraine, where sorghum is only beginning to be actively introduced, it can play a dual role: being an adaptive crop for unstable climate conditions and a source of economic growth thanks to its export potential (Ananda et al., 2020; Stoliar & Trembitska, 2024).

An important environmental advantage of sorghum is its ability to improve the sustainability of agroecosystems. Including sorghum in crop rotations helps reduce soil stress, improves organic matter balance, and reduces the need for water and fertilizers. The crop demonstrates natural resistance to several diseases and pests, which reduces the need for chemical protection (Kucher et al., 2022). However, these advantages are offset by the intensive spread and accumulation of harmful insects, which in some years can cause critical damage to production. However, the expansion of sorghum cultivation is accompanied by an increase in harmful insect populations, which is a serious limiting factor in the effectiveness of crop cultivation. According to global data, sorghum is affected by more than 150 species of phytophagous insects of various trophic groups: sucking (aphids, leafhoppers), leaf-eating (lepidopteran larvae), stem and soil pests (Guo et al., 2011; El-Gepaly et al., 2011; Minimassom, 2020; Nikolova, 2025). Their harmfulness can reach 30-72% of crop losses, especially when they spread extensively during critical phases of plant development-sprouting, panicle emergence, grain filling, and ripening (Guo et al., 2011; Dhaliwal et al., 2015; Oliveira et al., 2020; Nikolova, 2025).

Global research shows that the entomofauna of grain sorghum includes insect species that damage the plant at various stages of development: from germination to storage of the harvest (Guo et al., 2011; Szczepanek et al., 2018; Nikolova, 2025). Among the most dangerous groups are aphids (*Melanaphis sacchari*, *Rhopalosiphum maidis*), leafhoppers (*Cicadulina* spp.), stem moths (*Coniesta ignefusalis*, *Busseola fusca*), leaf-eating insects (caterpillars, locusts), and soil phytophages. Their harmfulness is complex: they reduce the photosynthetic activity of plants, disrupt the water balance, destroy the conducting system, damage the generative organs, and create secondary infection gateways for fungal and bacterial pathogens (Gurr et al., 2023; Nikolova, 2025).

Sugar or sorghum aphids (*Melanaphis sacchari* Zehntner) pose a particular threat, having spread rapidly across various regions of the world in recent decades. In the US and Mexico, this species has caused a sharp decline in crop yields and an increase in protection costs (Craigie et al., 2024; Du et al., 2025). Studies have shown that a single female can produce up to 75 offspring within 12 days, and population density can reach 30,000 individuals per plant. The damage causes chlorosis and necrosis of leaves, reduces photosynthetic activity, leads to the accumulation of honeydew and the development of sooty mold, which significantly impairs grain quality and complicates harvesting (Du et al., 2025; Jiao et al., 2025). A number of authors have proven that aphid infestation leads to a decrease in the diastatic activity of grain, an increase in losses during grinding, and a decrease in suitability for food processing (Van den Berg et al., 2003). The economic threshold of harmfulness is 37-102 individuals per m^2, exceeding which causes significant economic losses. At the same time, breeding studies have shown that the use of resistant hybrids can reduce the number of aphids by up to 80% and maintain yields at an economically viable level (Pekarcik & Jacobson, 2021).

In addition to aphids, other phytophages play an important role. The sorghum fly (*Atherigona soccata* Rondani) damages the central shoot of young plants, leading to their death and significant thinning of crops. In African and Asian countries, crop losses from this pest can reach 20-90% (Arora et al., 2025). The stem borer (*Coniesta ignefusalis* Hampson), common in West Africa, damages the stems of sorghum and millet, leading to lodging, reduced yields, and lower grain quality (Tanzubil, 2000). In combination with them, caterpillars of Lepidoptera and grasshoppers pose a threat, destroying vegetation and exacerbating losses in drought conditions.

For the Polissia region of Ukraine, where the crop is only just beginning to be introduced, there is a lack of systematic research on the species structure of pests, their harmfulness, and population dynamics. This creates a significant gap in scientific knowledge, complicates risk forecasting, and hinders the development of effective integrated protection systems. Given that regional conditions (acidic soils, uneven water regime, temperature fluctuations) contribute to the formation of unique agrocenoses, we can expect the emergence of a specific entomocomplex, different from other areas of Ukraine.

Therefore, studying the species composition and harmfulness of the sorghum entomocomplex in the Polissia region of Ukraine is an extremely important task. It will allow us to:

- identify and classify the main harmful species;
- study their seasonal dynamics and frequency of occurrence in different years;
- establish the dominant groups of phytophages;
- assess economic harm in the context of regional agroclimatic conditions.

In summary, one of the important components of adaptation to new agroclimatic conditions is the study of the harmful

entomocomplex that accompanies the cultivation of sorghum. Understanding the structure and dynamics of the sorghum pest population is a prerequisite for developing effective measures to protect this crop in a region where it is only just being actively introduced. Studying the species diversity of sorghum pests in the Polissya region of Ukraine allows us not only to identify potential threats to crop yields, but also to use the most effective strategies to combat them. Therefore, further research will be aimed at developing recommendations for integrated pest management strategies for the effective cultivation of grain sorghum in the Polissia region of Ukraine.

MATERIALS AND METHODS

The study of the species composition of Sorghum bicolor pests in Polissya of Ukraine was carried out during 2018-2024 by conducting crop surveys in the conditions of the educational and research field of Polissia National University and PE "Chaikivka" of Radomyshl district, Zhytomyr region. Records and observations of the spread of pests in agrocenoses were carried out according to the generally accepted method of entomological research: systematic visual inspections, by taking plant samples and accounting plots. Visual inspections (observation method) are the most common and are carried out by inspecting plants in the field. Pests can be identified by the type of damage, such as holes, rough eating, skeletonization, leaf curling, spots, galls, leaf discoloration, etc. This method provides general information about the number and activity of pests.

***Frequency*:** The survey is carried out at regular intervals (for example, once a week or every 10 days). Intervals: the inspection covers different parts of the field, diagonally or by the envelope method (at five points), in the amount of 100 plants.

The plant sampling method involves taking plant samples from different areas of the field for further analysis. Samples are taken according to a certain scheme (diagonally or by the envelope method)

Number of samples - 100 samples are taken per 1 hectare, which ensures the representativeness of the data, if the area is larger, then for each subsequent hectare plus 10 samples. Sampling is carried out at different stages of crop development, depending on the period of pest damage. The method of accounting plots is carried out in selected several standardized areas of the field where regular accounting is performed. Typically, plots of 10 m² or more are selected. The frequency of surveys is determined by intervals (e.g., every 10-15 days), depending on the phytophage. The number of pests on the plot is recorded in field logs for further analysis of the dynamics.

The pheromone trap method is designed to determine the number of certain types of insects, especially butterflies and other scale-winged pests. Pheromone pastes containing synthetic substances that mimic the smell of chlorine pheromones are used.

The frequency of occurrence is defined as the percentage of samples in which a species is detected, regardless of the number of individuals in the sample and taking into account the peculiarities of its seasonal population dynamics, i.e. the frequency of occurrence is given for the time of year when the species is active and its population is at its maximum. This value reflects only the presence (frequency) or absence of species in the agrobiocenosis and is not a quantitative characteristic in its pure form.

Scale of frequency of occurrence in the studied samples or plots. The assessment is carried out using the percentage of samples detected by the pest (Table 1).

Table 1. Scale of phytophage occurrence.

Percentage of samples with pests	Frequency of occurrence
1-10	low
11-30	medium
31-50	high
50 and more	very high

Pest abundance estimates show the number of individuals per unit area (Tables 2, 3, 4).

Table 2. Universal scale of phytophagous population.

Number of pests per plant	Numbers
Less than 1	low
1-5	medium
6 i more	high

Table 3. Scale for assessing damage to vegetative organs of plants on crops by gnawing insects.

Ball	Degree of damage	Damaged plants		Potential crop losses, %.
		%	grade point average	
1	Weak	to 25	1,5	to 5
2	Medium	25-50	1,6-2,0	5-15
3	Strong	>50	>2,0	>15

Table 4. Scale for assessing the damage to vegetative organs of plants on crops by insects with a spiny-sucking mouthparts.

Ball	The degree of population	Indicators of plant population
0	Absent	Not populated
1	Weak	Single individuals
2	Noticeable	5-25 %
3	Medium	26-50
4	Strong	51-75
5	Very strong	The whole plant is infested with the pest, withers, dries up

The meteorological conditions during the study period were characterized by unstable moisture: long periods of drought were followed by prolonged rains, and air temperatures repeatedly exceeded the long-term norm. Meteorological conditions during the study period (2018-2024) in Polissia of Ukraine were unstable and characterized by sharp fluctuations in precipitation and temperature. On average, the amount of precipitation during the growing season (May-September) ranged from 350 mm to 500 mm, which in some places exceeded the norm, but the distribution of precipitation was uneven: long periods of drought alternated with intense rains, which led to waterlogging of the soil.

The average monthly air temperature in the summer months exceeded the long-term norm by 2-3 °C, reaching an average of +30...+32 °C, and in some years there were maximums of up to +35 °C. Although abnormal weather conditions did not have a significant impact on sorghum yields due to its high drought tolerance, they significantly affected the dynamics of the spread of harmful insects, in particular by shifting the periods of their maximum activity. The statistical processing of the experimental data was carried out according to the generally accepted methodology using applied computer programs.

RESULTS

Under current conditions, an important reserve for increasing production and improving the quality of phytoproducts is the reduction of sorghum yield losses by limiting the spread of harmful organisms, particularly phytophagous pests, in the crop's phytocenoses. Phytophagous pests in *Sorghum bicolor* crops were detected throughout the vegetation period during the years of the study, affecting all parts of the plants. Click beetles damaged the sown seeds in the soil before they had a

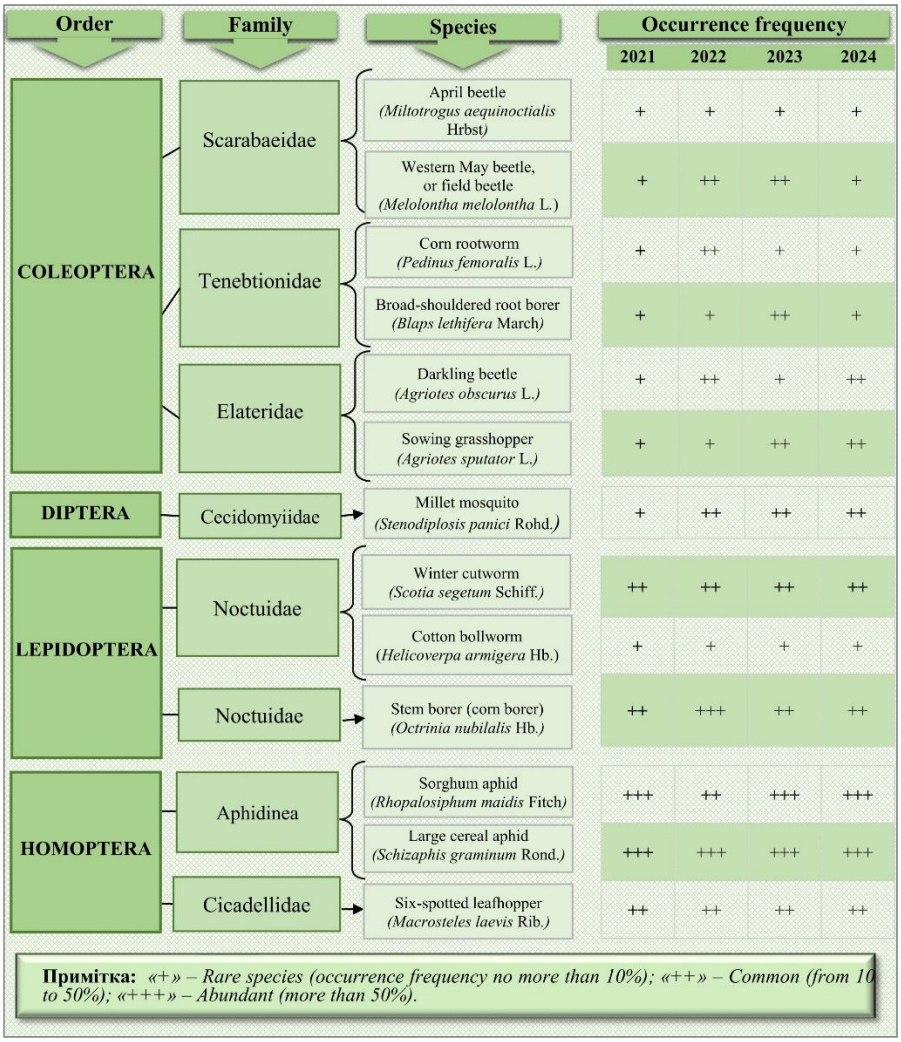

Figure 1. Species composition of phytophagous pests of *Sorghum bicolor* and their occurrence frequency in the Polissia region of Ukraine, 2021-2024.

chance to germinate. Typically, this pest consumes the embryo or damages the underground parts, leading to thinning of the crop. The young, still-weak sorghum seedlings were particularly vulnerable to damage from cutworm caterpillars, which caused thinning of the crops and significant yield losses. Cutworm caterpillars and stem borers damaged the stems and leaves, leading to plant death and a sharp decrease in productivity. Plants damaged by phytophages with piercing-sucking mouthparts (aphids, leafhoppers) experienced slowed growth and development, which resulted in reduced productivity and quality of the phytoproduct. The species composition of pests in sorghum crops during 2018-2024 was dynamic and depended on environmental factors (abiotic, biotic, anthropogenic), as well as plant development stages. The results of the monitoring indicated that pest infestation of sorghum plants began during the tillering phase, with pests such as click beetles, chafer beetles, rootworms, cutworm caterpillars, and aphids. During the booting phase, aphids and leafhoppers dominated, while during the flowering and grain ripening stages, aphids, stem borer caterpillars, and leafhoppers were the most prevalent.

The species composition of pests in *Sorghum bicolor* and their occurrence frequency are shown in Figure 1. During the monitoring of sorghum phytocenoses, harmful phytophagous pests were identified, including polyphagous species (chafer beetles, click beetles, cutworm caterpillars, and stem borers) and specialized pests (aphids, leafhoppers, and the millet gall midge). Aphids and leafhoppers are particularly harmful as vectors of plant viral diseases. The analysis of the species composition of phytophagous pests in sorghum crops reflects the presence of rare, common, and abundant pest species. Harmful phytophagous pests are those with an occurrence frequency greater than 50%, namely: the sorghum aphid (*Rhopalosiphum maidis* Fitch) and the large cereal aphid (*Schizaphis graminum* Rond), as well as in 2019, the stem borer (*Ostrinia nubilalis* Hb.).

A key aspect in determining the overall harmfulness of sorghum phytophagous pests is the assessment of seasonal pest population dynamics. This is based on the patterns of dominance of certain species over others, the occurrence frequency, and the extent of plant damage caused by harmful insects from the orders Coleoptera, Homoptera, Lepidoptera, and Diptera (Figure 2).

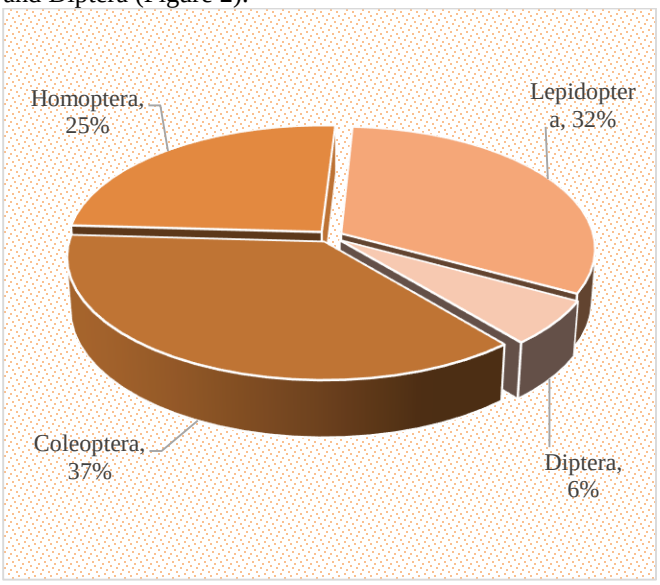

Figure 2. Species composition structure of the harmful entomofauna of *Sorghum bicolor* in the Polissia region of Ukraine, 2018-2024.

The harmful entomocomplex of *Sorghum bicolor* consists of four insect orders. The order Coleoptera (beetles) exhibited the greatest species diversity, with 6 species, accounting for 37% of the complex. These species belonged to three families: *Scarabaeidae*, *Tenebrionidae*, and *Elateridae*. The order Lepidoptera (moths and butterflies) occupied the second position in the structure, represented by three species from two families: *Noctuidae*, with a share of 32%. The order Homoptera (aphids and leafhoppers) made up 25% of the entomocomplex, represented by 3 species from two families: *Aphidinea* and *Cicadellidae*. Only one species from the order Diptera (flies), belonging to the family *Cecidomyiidae*, was present, accounting for 6% of the complex. The study revealed that the species composition of the harmful entomocomplex of *Sorghum bicolor* depends on the stage of the plant's organogenesis. It forms due to migrating pest

Table 5. Infestation of *Sorghum bicolor* by pests during the vegetation period of the crop, 2018-2024.

Pest	Vegetation period										
	May		June			July			August		
	2	3	1	2	3	1	2	3	1	2	3
Cotton bollworm											
Soil pests											
Aphids											
Millet mosquito											
Corn borer											

species from other biotopes and polyvoltine species that are already developing in this phytocenosis (Figure 3).

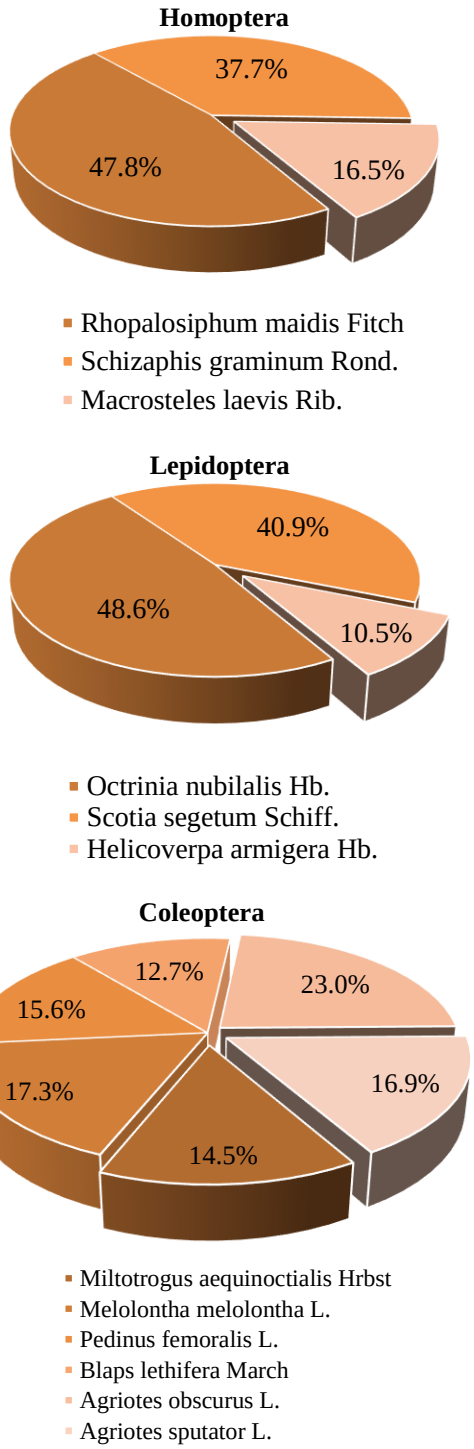

Figure 3. Structure of the dominant pest species of Sorghum bicolor in the Polissia region of Ukraine, 2018-2024.

Phytophagous pests in sorghum crops damaged the plants throughout the entire growing period. However, there were certain pest species that only caused damage at specific stages of the crop's organogenesis (Table 5).

The cotton bollworm was the most dangerous pest for sorghum crops during July and August. Soil pests attacked the crops at the beginning of the growing season-during May and the first decade of June. Aphids were present throughout most of the growing period, from June to the first decade of August. The sorghum midge damaged the plants only in July. During the active growth phase, the stalk borer was particularly harmful and dangerous, from the last decade of June to August. The species composition of pests changed throughout the years of the study, as it was influenced by environmental factors: abiotic, biotic, and anthropogenic, as well as the phenophases of Sorghum bicolor development. Particularly harmful pests in the crop's phytocenoses were: *Rhopalosiphum maidis* Fitch, *Schizaphis graminum* Rond., *Octrinia nubilalis* Hb., *Scotia segetum* Schiff., *Macrosteles laevis* Rib, and others. The global demand for sorghum grain is increasing. According to forecasts, by 2050 the global population will exceed 9 billion people, making it a priority to ensure adequate and high-quality food supply. In this context, ensuring timely and high-quality protection of agricultural crops, especially from pests, with ecologically safe systems, deserves special attention. It is also urgent to control the formation of resistant populations of harmful organisms. Therefore, the protection of sorghum should be comprehensive, based on the biology and phenology of the main phytophagous pests, which allows for optimizing protective measures against key pest species. It is important to note that this issue has not been studied in the Polissia region of Ukraine, making it highly relevant and necessary for research.

DISCUSSION

The study of the species diversity of the grain sorghum entomocomplex conducted by a number of scientists shows a significant diversity of species that damage this crop. According to their data, the harmful entomocomplexes of sorghum include representatives of the families Curculionidae, Cicadellidae, Noctuidae and Chrysomelidae (Chaâbene et al., 2015; Minimassom, 2020). According to the research of Singh (2023), cicadas from the family Cicadellidae cause the greatest damage in the phase of panicle ejection of sorghum, their number in some cases can reach 25 individuals per square meter, which significantly reduces the photosynthetic activity of plants.

According to the research of Boiko M. O. (2020), one of the main pests of sorghum is the weevil (*Sitophilus granarius*), which can account for up to 40% of the entire entomocomplex, damaging plants during grain ripening. This leads to a decrease in quality and yield. In the study by

Okosun O. (2021), it was found that damage to plants at the stage of flowering and grain filling can lead to a loss of up to 30% of the yield, especially in areas with high humidity and temperature.

In general, the results of the conducted studies show that the greatest damage to sorghum is caused by the May beetle, which damages the roots, leaves and stems, and can destroy up to 15-20% of the crop (Ren et al., 2017). At the same time, studies have shown that under conditions of intensive use of pesticides and the application of agrotechnical measures, such as deep plowing, the number of pests is significantly reduced, which has the potential to control agrotechnical methods (Ahmad et al., 2016). Other authors also note the importance of integrated pest management approaches, where the use of biological control agents such as predatory insects and parasites can reduce pest populations by 25-35% (Hammer et al., 2014). Minimassom (2020) points out the need to improve the selection of sorghum varieties and hybrids with increased resistance to major pests. According to his research, resistant varieties can reduce yield losses by 20-25%. Thus, it can be argued that Sorghum bicolor pest control in Ukraine should include an integrated approach, combining agronomic, biological and chemical control methods. Studies show that to achieve optimal results, it is necessary to control not only the species diversity of sorghum pests, but also to take into account the specifics of climatic conditions and agronomic practices of growing the crop. The absence of resistant sorghum varieties in Ukraine includes the selection of the most effective pest control methods and requires further research in the area of breeding.

***Conclusion*:** The harmful entomofauna of *Sorghum bicolor* in the Polissia region of Ukraine is represented by four insect orders: Coleoptera, Homoptera, Lepidoptera, and Diptera, which include 13 pest species from 8 families. The intensity of pest reproduction and spread depended on environmental factors and the plants' resistance. The dominant and most harmful species were *Rhopalosiphum maidis* Fitch, *Schizaphis graminum* Rond., *Octrinia nubilalis* Hb., *Scotia segetum* Schiff., and *Macrosteles laevis* Rib. Knowledge of the pest species composition of sorghum significantly impacts the development and implementation of measures to limit their spread and harmfulness.

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Mykola Kravchuk: supervised, reviewed and edited the original draft.

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***Ethical statement*:** Authors declare no potential conflict of interest.

***Availability of data*:** All data used are within the manuscript.

***Consent to participate*:** All authors consented to publish this research article in JGIAS.

***Informed consent*:** Written informed consent was obtained from all participants regarding publishing their data and photographs

***SDGs addressed*:** No poverty; Zero hunger; Climate action

***Policy referred*:** Law on Pesticides and Agrochemicals (Law No. 86/95-BP); Law on Plant Protection (Law No. 180-XIV).

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